

POSSIBILITIES OF IMPROVING EATING QUALITY OF SHIPPED FRESH CORN WITH THE HIGH SUGAR RETENTION PROPERTY OF THE SHRUNKEN 2 CHARACTER

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There are several gene mutations in corn which produce striking differences from normal in texture, form, and amount of endosperm in the mature kernels. One such mutant, *su*, causes the "sugary" characteristic in present commercial sweet corn hybrids. Another mutant gene influencing sugar content, *shrunken₂* (*sh₂*) reported by Mains (3) in 1948, has been under investigation at the Everglades Station since 1956.

Laughnan (1) in 1953 reported that mature *shrunken 2* kernels with the normal *Su* or starchy gene (*Sush₂*) contained about four times as much total sugar as sweet corn kernels (Table 1) and had a pleasant malty flavor. The high sugar content was accompanied by lower starch content. Weight of the *shrunken 2* (*Sush₂*) kernels was also about 80% that of the regular sugary endosperm kernels.

Dry, mature kernels possessing the *shrunken 2* (*Sush₂*) factor are more collapsed than sugary (*suSh₂*) endosperms. Their axial and abaxial surfaces are invariably concave, and their sides and crown region have one to several deep depressions. The prominent ridges bordering the *shrunken* area of these kernels are either straight or gently curved (Fig. 1). They resemble regular field corn or starchy (*SuSh₂*) kernels in being relatively opaque. In contrast, sugary endo-

sperms are translucent and may have only slight or no depressions of the axial or abaxial surfaces; the areas of collapse on the crown are more numerous than on the *shrunken* kernels, are angular in outline and not as smoothly rounded in cross section (1). Since high levels of sugars and polysaccharides greatly influence eating quality of sweet corn, studies were undertaken to determine whether the *shrunken 2* high sugar characteristic might be utilized to improve eating quality of shipped fresh market corn. Because sugary-*shrunken* kernels containing both *su* and *sh₂* (*sush₂*) are extremely collapsed (Table 1), studies have been confined to *sh₂* in the presence of the *Su* or starchy gene.

EARLY EXPERIMENTS AT BELLE GLADE

Two of Laughnan's *shrunken 2* corn lines were grown at Belle Glade in the spring of 1956. Ears from these lines harvested at fresh market maturity were very sweet after 9 days storage at 40°F and far superior in eating quality to regular sweet corn stored under similar conditions. Sugar and insoluble solids determinations on a small number of ears from each line showed 4.5% to 5.0% sucrose in the *sh₂* kernels at harvest compared to 2.3% for Golden Security sweet corn. One *sh₂* line still showed 4.4% sucrose after 17 days storage as compared to 1.4% for Golden Security. In the spring of 1957, a taste panel of 11 participants rated ears which contained the *shrunken 2* factor and had been stored for 13 days at 40°F as far superior to both fresh and stored sweet corn checks. Comparative sugar analyses of the *sh₂* lines in this

Table 1. Composition and weight of four types of mature corn endosperms as reported by Laughnan in 1953.

Type	Phenotype	Wt/kernel grams	Reducing sugars percent	Sucrose percent	Total sugars percent	Water soluble polysaccharides percent	Starch percent	Total carbohydrates percent
Starchy	<i>SuSh₂</i>	0.185	0.33	1.44	1.77	1.3	65.0	68.0
Sugary	<i>suSh₂</i>	0.166	1.87	2.66	4.53	35.8	30.0	70.0
<i>Shrunken₂</i>	<i>Sush₂</i>	0.139	2.69	16.13	18.82	1.6	24.0	45.0
Sugary- <i>shrunken</i>	<i>sush₂</i>	0.113	4.00	28.00	32.00	1.8	7.7	41.2

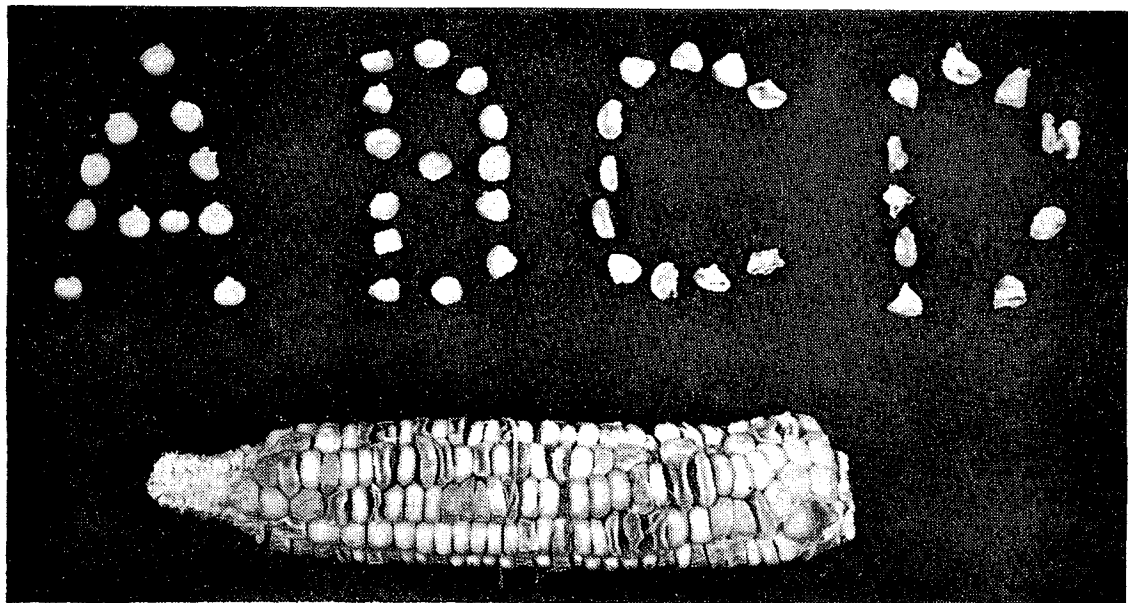


Figure 1.—Mature corn ear showing segregation of (A) starchy, (B) sugary, (C) Shrunken, and (D) sugary-shrunken kernels. Note (C) the smooth collapsed appearance of the shrunken kernels compared with the more minutely wrinkled crowns of the (B) sugary kernels, and (D) the extremely collapsed sugary-shrunken kernels. (A) is starchy or normal field corn kernels.

test and a sweet corn hybrid are given in table 2.¹

PROBLEMS ENCOUNTERED WITH THE SH₂ CORN LINES

Mains (3) stated that germination of sh₂ seed was good under favorable conditions. During 1956 and 1957 on Everglades peaty-muck soil, field germination from shrunken 2 kernels

¹See acknowledgements.

was poor under excessively wet soil conditions but as good or nearly as good as regular sweet corn kernels under normal conditions. Experiments conducted during this period showed no significant differences in germination between small, medium, and large kernels within individual sh₂ lines under excess soil moisture; however, differences were noted between lines, indicating that lines with good germinating ability might be developed.

Table 2. Comparison of reducing sugars, sucrose and total sugars in Golden Security and an sh₂ line harvested at optimum fresh market maturity May 23, 1957 and stored for 13 days.

Hybrid or line	Days in storage at 40°F	Reducing sugars percent	Sucrose percent	Total sugars percent
Golden Security	1	0.75	1.74	2.48
Golden Security	13	0.69	0.90	1.60
sh ₂ (56-1824)	13	0.34	5.12	5.46

Ears within lines homozygous for the sh_2 factor varied considerably in taste. Sugar content of 12 ears from one sh_2 line varied in sucrose content from 2.4% to 5.2%, indicating that modifying factors were present. This precludes the use of a simple straight backcross breeding system based on visual selection of segregates to incorporate the desired sugar retention factor of the sh_2 line into sweet corn lines.

CONSUMER ACCEPTANCE OF ILLINICHIEF²—A RELEASED SH_2 HYBRID

In March 1960, 1½ acres were planted to the then newly released sh_2 hybrid Illinichief on the A. Duda Farm at Belle Glade. A satisfactory field stand was obtained by a heavy seeding rate. The Illinichief plants were severely affected by *Helminthosporium turcicum* Pass., very irregular in maturity, and produced many poorly pollinated ears with long unfilled ear tips. The ears were not marketable on the regular sweet corn fresh market. In cooperation with R. K. Showalter, Department of Food Technology and Nutrition, Florida Agricultural Experiment Station, Gainesville, ears were harvested and trucked to the Dickman Farm at Ruskin, Florida where they were husked, sorted, trimmed and prepackaged in attractive polyethylene film packages. Four and five days later 2200 packages were distributed through a supermarket in Winter Park, Florida with a self addressed post card questionnaire on each package requesting the consumers opinion of the corn (4). Approximately 75% of the 447 consumers who returned the cards indicated that the corn was sweet, better than the corn they had been getting, and that they liked it. Approximately 20% thought the corn was too sweet and disliked it. Other comments were made that the pericarp was too tough and/or that the texture was watery. The latter two comments are undoubtedly a result of close parental relationship of Illinichief to the Iochief sweet corn hybrid which has kernels with a rather tough pericarp and watery texture. Concurrent with the Winter Park test, 25 Illinichief packages were distributed to Experiment Station staff and to others in the Belle Glade area. Consumer reaction from this sampling was about the same as that obtained in Winter Park except that a smaller percentage of the consumers rated the corn better than they had been getting. However, the total percentage of consumers rating the corn as good or better was about the same in both samplings. Similar con-

sumer response has been obtained with sh_2 ears from experimental hybrids and breeding material grown during these studies. Correspondence with Laughnan (2) indicated that response of home gardeners and market gardeners who have tried Illinichief has been "phenomenal" and that the distributor, Illinois Seed Producers, has had difficulty satisfying demand for the seed. The Illinois Seed Producers report that about 10 to 15% of the people have considered it too sweet.

RECENT STUDIES AT THE EVERGLADES STATION

Because of the favorable consumer response to Illinichief, a number of the best-germinating shrunken 2 lines developed at the Everglades Station during the previous breeding and testing work were combined into experimental F¹ hybrids and planted in late February 1961 with their parent inbreds. Field germination and vigor of eight of the hybrids and several of the inbreds were comparable to the sweet corn checks. One of these eight hybrids produced ears which, in the opinion of the author and several others, were not too sweet at harvest, yet were still sweet and tender after two weeks storage at 40°F. Kernels of this particular hybrid are broader than desired by fresh market buyers and the ears have poor husk protection and flags. However, field performance of this hybrid and its eating quality, which is much superior to Illinichief, indicates that a desirable fresh market hybrid with the sh_2 factor might be developed.

Seed of three experimental sh_2 hybrids were sent to South Carolina, Wisconsin, and Idaho in the spring of 1961. Satisfactory stands, though in most cases a little less than for the sweet corn checks were obtained in 3 of the 4 locations (Table 3). In Wisconsin, temperatures in the low 30's for about a week after planting resulted in very poor germination. Germination of 17 thirty-kernel lots of sh_2 lines sent to Idaho for increase in early May 1961 ranged from 27 to 100 percent averaging 58% germination. Four of the 17 lots gave 75% or better germination as compared to the 50 to 93% (average of 76%) for the three regular sweet corn lines in the planting.

Plantings of 200 to 350 thirty-kernel plots of sh_2 lines, sub lines, and a number of hybrids at Belle Glade in the fall of 1961 and the spring and fall of 1962 have given satisfactory field stands. Five experimental sh_2 hybrids sent to Charleston, South Carolina in the spring of 1962 gave poorer stands than the check but two did give 80% germination or better. In 1962 test plantings in Idaho and Wisconsin, stands of

²Also distributed as Illini Super Sweet.

Table 3. Comparative field germination percentages of three experimental sh₂ Everglades Station hybrids at 5 locations in 4 states in the spring of 1961.

	Belle Glade	S. Carolina V.B.L.	Idaho Caldwell	Idaho Idaho Falls	Wisconsin Columbus
Check (su)	75	-	100	95	100
61-642	80	100	100	80	-
61-664	65	45	70	65	30
61-665	65	65	70	70	15

the best sh₂ hybrids were comparable to the checks. This indicates that inherent poor germination of some shrunken 2 lines can be improved.

Sugar analyses by the U. S. Vegetable Breeding Laboratory at Charleston on ears from six Everglades Station experimental sh₂ hybrids in 1961 ranged from 6.47 to 8.49% total sugar at 25% dry matter.

DISCUSSION AND SUMMARY

A high level of sugar is an important factor determining eating quality of sweet corn. This sugar is rapidly converted to starch after harvest and kernels contain very little if any sweetness upon reaching distant consumers. Ears containing a mutant endosperm character, shrunken 2, which appears to block the conversion of sugar to starch during kernel maturation, may range in total sugar content from slight to more than double that in regular sweet corn at the fresh market stage. The sh₂ ears also have a much higher total sugar content after storage at 40°F for several days. In addition, kernels containing the sh₂ factor dent more slowly and have a much better appearance than regular sweet corn after several days storage. Consumer acceptance tests show that about three fourths of the people like the sweetness and rather crisp, different flavor of the sh₂ ears while about 20% have thought them too sweet. Considerable differences in sugar content and taste have been found among sh₂ lines and experimental sh₂ hybrids. Hence, it should be possible to develop sh₂ hybrids with less pericarp and sugar content than is found in the one sh₂ hybrid now commercially available.

Such sh₂ hybrids would give consumers of shipped fresh market corn ears with much higher sugar content and better eating quality. Greatly increased demand for fresh market corn should result.

Kernels containing the sh₂ factor do not germinate as well as sweet corn at low soil temperatures or in excessively wet soil. However, under normal conditions in muck soil, field stands of some lines and experimental hybrids have been equal to or nearly equal to the sweet corn checks. It appears that it may be possible to develop desirable sh₂ hybrids which with good fungicide seed treatments will give satisfactory stands.

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